## Claims

What is claimed is:


1. A method for analyzing a circuit network, comprising:

5       representing a circuit network by using a matrix of nodes

having fine nodes and coarse nodes;

applying an adaptive coarse grid construction procedure

to assign grid nodes in the matrix as either coarse grid nodes

or fine grid nodes according to (1) circuit activities and (2)

10    a matrix structure of the matrix to construct a plurality of

levels of grids with different numbers of nodes to

respectively represent the circuit network; and .

applying iterative smoothing operations at selected local

fine grids corresponding to active regions at a finest level

15    obtained in the adaptive coarse grid construction procedure.


2. The method as in 1, wherein the coarse grid nodes are

divided into non-adaptive coarse nodes which are selected

according to the matrix structure, and adaptive coarse nodes

20    which are selected according to circuit activities.


3. The method as in claim 2, wherein, in assigning non-

adaptive coarse nodes, a node with a maximum potential in its

degree is selected as a first non-adaptive coarse node and

25    each neighboring node of the first non-adaptive coarse node is

temporality assigned as a fine node, and wherein a potential

of each neighboring node of the first non-adaptive coarse node

is increased by one unit before a next level of assigning

coarse and fine grid nodes so that each fine node has at least

one neighboring coarse node upon completion of assigning non-

5    adaptive coarse nodes.


    4. The method as in claim 2, wherein an adaptive coarse

node is selected according to a first-order derivative of a

nodal voltage.

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    5. The method as in claim 4, wherein a coarse node is

selected as an adaptive coarse node when the first-order

derivative the coarse node is greater than a threshold value.


15    6. The method as in claim 5, further comprising selecting

adaptive coarse nodes in a level that is not the finest level.


    7. The method as in claim 1, after the iterative

smoothing operations in a level, further comprising:

20        applying a restriction mapping of nodes in the level to a

next level with less nodes;

        performing iterative smoothing operations again at the

next level; and

        repeating the restriction mapping and the iterative

25    smoothing operations until reaching a level of nodes which are

solvable by a direct matrix solving method such as a Gaussian

elimination method.


        8. The method as in claim 1, after the iterative

5   smoothing operations in a level, further comprising:

        applying an interpolation mapping of nodes in the level

to a next level with more nodes;

        performing iterative smoothing operations again at the

next level; and

10        repeating the interpolation mapping and the iterative

smoothing operations until reaching the finest level of nodes.


        9. The method as in claim 8, further comprising:

        computing a residual value of an error after the

15   iterative smoothing operations at the finest level;

        comparing the residual value to a pre-determined

threshold;

        terminating any further processing when the residual

value is less than the threshold; and

20        when residual value is greater than the threshold, the

method further comprising:

        applying a restriction mapping of nodes in the finest

level to a next coarser level with less nodes,

        performing iterative smoothing operations again at the

25   next coarser level; and

repeating the restriction mapping and the iterative

smoothing operations until reaching a coarsest level of nodes

which is solvable by a direct matrix solving method such as a

Gaussian elimination method,

5          applying an interpolation mapping of nodes in the

coarsest level to a next finer level with more nodes,

performing iterative smoothing operations at the next

finer level,

repeating the interpolation mapping and the iterative

10   smoothing operations until reaching the finest level of nodes,

and

repeating the restriction mapping, the interpolation

mapping and the respective iterative smoothing operation at

different levels until the residual value at the finest level

15   is less than the threshold.


10. The method as in claim 1, further comprising

dynamically changing designations of active and inactive

regions of the circuit network according to circuit activities

20   at different times.


11. The method as in claim 10, further comprising

applying iterative smoothing operations in active regions more

frequently in time than in inactive regions.

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12. The method as in claim 1, further comprising: in a passive linear circuit, applying different models to passive circuits exhibiting resistance and capacitance without inductance and passive circuits exhibiting inductance.

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13. The method as in claim 12, further comprising separating nodal voltages and branch currents into different vectors during processing to make a system matrix to be symmetric and positive definite.

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14. A method for analyzing a circuit network, comprising:

representing a circuit network by using a plurality of levels of grids with different numbers of nodes to represent the circuit network according to an algebraic multigrid

15   method;

applying a restriction mapping from one level to a next coarser level to propagate computation results of the one level to the next coarse level;

applying an interpolation mapping from one level to a

20   next finer level to propagate computation results of the one level to the next finer level;

performing an iterative smoothing operation at each level to obtain computation results of each level comprising states of nodes in each level; and

25      repeating (1) the restriction mapping and the iterative smoothing operation from the finest level to the coarsest

level and (2) the interpolation mapping and the iterative

smoothing operation from coarsest level back to the finest

level for at least one time to obtain a solution to the

circuit network.

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15. The method as in claim 14, wherein the coarsest level

is a level where a matrix equation for nodes in the level is

solvable by a direct matrix method such as the Gaussian

elimination method.

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16. The method as in claim 14, wherein at least one level

includes nodes corresponding to only selected circuit regions

in the circuit network that are active and does not include

nodes corresponding to inactive circuit regions in the circuit

15   network.

17. The method as in claim 14, further comprising:

assigning regions in the finest level with nodes

corresponding to active circuit regions in the circuit network

20   as active local fine grids; and

performing the iterative smoothing operation only in the

active local fine grids in the finest level to obtain

computation results of the finest level.

25       18. The method as in claim 14, further comprising:

assigning regions in a level with nodes corresponding to

active circuit regions in the circuit network as active local

grids and other regions in that level as in inactive grids;

and

5       performing the interactive smoothing operation in an

active local grid more frequently than in an inactive grid.


19. The method as in claim 14, further comprising

10  applying an adaptive coarse grid construction procedure to

assign grid nodes in the matrix as either coarse grid nodes or

fine grid nodes.


20. The method as in claim 19, wherein a coarse node is

15  assigned by:

assigning a node with a maximum potential to its degree

as a first coarse node and all neighboring nodes as initial

fine nodes;

for each of the initial fine nodes, increasing a

20  potential of each of neighboring nodes by one unit;

assigning a node which has a maximum potential among

other nodes except for the first coarse node as a second

coarse node; and

repeating the assigning for nodes that are not assigned

25  as coarse nodes until all nodes are assigned.

21. The method as in claim 19, wherein the coarse nodes are selected according to their values of a first-order derivative of a nodal voltage.

5      22. A method for analyzing a circuit network, comprising:

applying an algebraic multigrid method to a matrix representative of a circuit network to construct a plurality of matrices with different degrees of coarsening grids;

representing regions in the circuit network exhibiting

10     active circuit activities with active grids and regions in the circuit network exhibiting less active circuit activities with inactive grids; and

performing an iterative smoothing operation in an active grid more frequently than in an inactive grid to reduce an

15     amount of computation.

23. The method as in claim 22, further comprising:

applying a restriction mapping of nodes in a coarse grid to a next coarser grid;

20     performing the iterative smoothing operation at the next coarser grid; and

repeating the restriction mapping and the iterative smoothing operation until reaching the coarsest grid which has a matrix equation that is solvable by a direct matrix solving

25     method such as a Gaussian elimination method.

23. The method as in claim 22, further comprising:

applying an interpolation mapping of nodes in one grid to a next finer grid;

performing the iterative smoothing operation at the next

5    finer level; and

repeating the interpolation mapping and the iterative smoothing operation until reaching the finest grid.

25. An article comprising a machine-readable medium that

10   stores machine-executable instructions, the instructions causing a machine to:

apply an algebraic multigrid method to a matrix representative of a circuit network to construct a plurality of matrices with different degrees of coarsening grids;

15   divide the circuit network into active regions and inactive regions according to circuit activities; and

perform an iterative smoothing operation in an active region more frequently than in an inactive region.

20   26. The article as in claim 25, wherein the machine-executable instructions further comprise instructions that cause the machine to perform an iterative smoothing operation to solve for a matrix equation of each grid and to map a computation result of each grid to a next finer or coarser

25   grid until a residual error of a solution is less than a pre-determined threshold.